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Wealth, Wages, and Wedlock: Explaining the College Gender Gap Reversal*

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Abstract

In this paper, I study the role of changes in the wage structure and expectations about marriage in explaining the college gender gap reversal. With strongly diminishing marginal utility of wealth and in the presence of a gender wage gap, single women have a greater incentive than single men to invest in education. Marriage-market distortions tend to depress the overall benefit of education for women relative to men. I develop a tractable two-period model and parameterize it using US census data for the cohort born in 1950. I then show that it can generate a reversal and that the most important driving force for this is the decline in marriage rates.

Keywords: Education; gender wage gap; home production; marriage

JEL classification: D13; I24; J12

I. Introduction

Over the last decades, women have caught up with men in many domains, but nowhere has the change been so striking as for college education. Not only did they manage to close the gap, nowadays women even graduate in larger numbers in most developed countries. This is known as the “college gender gap reversal” (see Goldin *et al.*, 2006). To illustrate this phenomenon for the United States (US), Figure 1(a) plots the fraction of females and males who have completed four years of college or more at the age of 40 by birth year. Whereas in the 1950 cohort about 30 percent of the men obtained a college education versus 25 percent of the women, by 1970 the fraction of educated women had surpassed that of men. The same pattern shows up in the enrolment rates for tertiary education (see Figure 1(b)). Both in the US and for the European Union

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Fig. 1. The college gender gap reversal

Sources: (a) Integrated Public Use Microdata Series for 1970–2010; (b) United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute for Statistics.

(EU) countries, the ratio of female to male enrolment has increased over time and nowadays exceeds 100 percent.

In this paper, I study the role of changes in the wage structure and expectations about marriage in explaining this phenomenon. I develop a tractable two-period model with the following main features. First, individuals differ in their talent for schooling and thereby the utility cost that they have to incur when pursuing higher education. Second, there is a gender wage gap in the sense that women earn less than equally qualified men. I assume that men and women are the same in all other respects, including a common college wage premium. Third, individuals derive utility from a consumption good that is produced using time and market goods. The wage that they can earn in the market is the opportunity cost of the time spent at home. Finally, in the second period of life, some individuals get married while others stay single. The probability of marriage and the degree of sorting are exogenous, but matching probabilities are determined in equilibrium.

I show that all individuals whose utility cost of schooling is below a certain gender-specific threshold decide to get educated. This threshold value can be decomposed into two main components: a labour-market benefit of education and a distortion due to the possibility of marriage. I prove analytically that the labour-market benefit of education for women can be higher than for men if there is a sufficient amount of curvature in the utility function. Intuitively, this is because women earn lower wages, and with strongly diminishing marginal utility of wealth, they have more to gain by increasing their lifetime earnings through obtaining a college degree. The distortions caused by the marriage market tend to depress the overall benefit of education for women relative to men, as they expect to marry a more wealthy spouse and to spend more time on home production.

I then parametrize the model using US census data for the cohort born in 1950. For this cohort, more men than women go to college (see Figure 1). If I subsequently change the probability of marriage, the gender wage gap and the college wage premium in line with empirical observation, then the model predicts a reversal of college graduation rates for the cohort born in 1970. The analysis shows that the most important driving force for this reversal is the decline in marriage rates.

Relationship to the Literature. Prior to the reversal in college graduation rates, most research on gender differences in educational attainment naturally focused on the question of why men would be more educated than women. The fact that women spent more time at home instead of working in the labour market seemed like a reasonable explanation. Recently, a body of literature has emerged that attempts to account for the reversal. For example, Chiappori *et al.* (2009) propose that there has been a change in social norms about household roles that ensures that women are no longer tied up at home, but can take advantage of a higher college wage premium in the labour market. In the context of an endogenous search-and-matching model of the marriage market, Guvenen and Rendall (2015) find that the rise in divorce risk over the last decades following a legislative reform has increased the insurance value of education more for women than for men, as they tend to get custody of the children. The explanation put forward by Becker *et al.* (2010) relies on gender differences in the distribution of non-cognitive skills (such as self-motivation and discipline) that are inversely related to the cost of education. If women have a higher level of these skills on average, and the variability among them is lower, then the supply of female college graduates is more responsive to changes in the economic environment that increase the payoff of a college education. Greenwood *et al.* (2016) develop and estimate a large-scale model of marriage, labour-force participation, and educational attainment to explain the changes in US households between 1960 and 2005. By allowing for gender-specific shifts in the utility cost of education over time, they manage to match the college graduation rates by gender in both years. Fernández and Wong (2011) aim to quantitatively explain the difference in behaviour between two cohorts of women, those born in 1935 and in 1950. Their approach differs from that of Greenwood *et al.* (2016) in that they allow for intertemporal consumption and savings decisions, but take marriage and divorce probabilities as given. They find an important role for changes in the probability of divorce and the wage structure. Finally, there are studies that stress the preferences of parents in the educational investments of their children. Examples include those of Sánchez-Marcos (2007) and the recent contribution by Hazan and Zoabi (2015).

The main contribution of this paper is to highlight the economic mechanisms that result in a college gender gap reversal in a stylized setting. These mechanisms are also at play in most of the more comprehensive models referred to above but are partly obscured by their complexity. I show that the degree of curvature in the utility function crucially affects the ability of the model to generate a college gender gap reversal in response to observed changes in wage rates and marriage probabilities over time. The importance of the shape of the utility function in explaining gender differences in educational attainment has also been stressed by Ríos-Rull and Sánchez-Marcos (2002). However, in their model, parents decide about the education of their children and the aim is to explain why even risk-averse parents would want to educate their sons more than their daughters. In contrast, this paper provides a theory of both the initial college gender gap and the subsequent reversal.

It is important to stress here that my results do not rely on a higher college wage premium for women (the evidence for which is mixed, as will be discussed below) or differences in the distribution of the utility cost of education between the sexes or over time. Some of the previous studies were able to numerically generate a college gender gap reversal only by allowing for an exogenous change in the parameters that govern the utility cost of education. For example, Greenwood *et al.* (2016) require a substantial decline in the average cost of education for women relative to men in order to match the college graduation rates by gender for both years. Similarly, Fernández and Wong (2011) do not obtain a reversal in their baseline calibration and can account for it only by decreasing the cost parameter for women and increasing that for men. Guvenen and Rendall (2015) keep the cost distribution constant over time, but its standard deviation is assumed to be the same for men and women while the estimated mean is higher for women. This is clearly at odds with the evidence cited in Becker *et al.* (2010) that women have a lower cost on average and that there is less variability among them.

The remainder of this paper is organized as follows. I describe the model in Section II. In Section III, I decompose the benefit of education into several parts and highlight potential gender differences. The model is parametrized in Section IV in order to illustrate the mechanisms of the college gender gap reversal in Section V. Section VI concludes. The paper contains several appendices with technical details.

II. Model

In this section, I extend a standard two-period model of intertemporal choice with home production, a simple marriage market, and a unitary decision-making framework for married couples.

Fig. 2. Overview of model periods

Individuals

Individuals of gender $j \in \{f, m\}$ enter the economy as adults and live for two periods (see Figure 2). At the start of period 1, the individuals learn their utility cost of education θ , which is drawn from a distribution F . Given this information, they decide whether to pursue tertiary education ($E = 1$) or not ($E = 0$). Subsequently, they make decisions about hours worked at home, expenditure on market goods, and the amount of savings. At the end of the first period, there are four different types of individuals: uneducated men, educated men, uneducated women, and educated women. In the second period, some of them get married (with an exogenous probability q) while the remainder stay single. Couples and singles then again decide how much to consume and how to divide their time between working at home and in the labour market.

In line with many papers in the literature, I assume that an individual's felicity function is of the isoelastic form,

$$u(c) = \begin{cases} \frac{c^{1-1/\sigma} - 1}{1 - 1/\sigma} & \text{if } \sigma \neq 1, \\ \ln c & \text{if } \sigma = 1 \end{cases} \quad (1)$$

where $\sigma > 0$ is the intertemporal substitution elasticity. Following Guvenen and Rendall (2015), the consumption good is created using the following home production technology,

$$g(x, n) = \begin{cases} [vx^{1-1/\gamma} + (1-v)n^{1-1/\gamma}]^{1/(1-1/\gamma)} & \text{if } \gamma > 0, \gamma \neq 1 \\ vx^{1-1/\gamma} & \text{if } \gamma = 1 \end{cases} \quad (2)$$

$$0 \leq v \leq 1,$$

where x is the input of market goods (available at price p) and n is home time. The parameter $\gamma > 0$ equals the elasticity of substitution between the two inputs. If $\gamma > 1$, then time and goods are gross substitutes in production; if $\gamma < 1$, then they are gross complements. Home time is itself created according to

$$h(n^f, n^m) = [(n^f)^{1-1/\xi} + (n^m)^{1-1/\xi}]^{1/(1-1/\xi)}, \quad \xi > 1, \quad (3)$$

which implies that men and women are equally productive and (possibly imperfect) substitutes in home production. Note that for a single woman, $n = n^f$, and for a single man, $n = n^m$. The fraction of the unit time endowment not spent producing consumption goods at home is supplied to the labour market and earns a wage $w^j(E)$ that depends on both gender and education level. In period 1, individuals can choose to save part of their labour income at an interest rate r for use in the second period. In the remainder of this section, I describe the optimal choices of individuals using backward deduction, starting with singles and married couples in period 2 followed by the education choice in period 1.

Singles in Period 2. A single of gender j enters period 2 with a certain education level E and a stock of savings a_2 . This individual wishes to maximize utility (1) subject to a budget constraint and given the home production technology as described by equations (2) and (3). The solution to this problem can be obtained in two steps. First, for a given amount of home production, the optimal choice of time input and market goods is such that the associated cost is minimized. I denote by $\eta[p, w^j(E)]$ the minimum cost function for one unit of the consumption good.¹ It is increasing in the price of market goods p and the opportunity cost of time $w^j(E)$. In the second step, the individual will optimally choose how much to consume out of total financial and human wealth $W_2^j(E, a_2) = [1+r]a_2 + w^j(E)$. As this is the last period of life, no assets will remain. The resulting utility level is given by

$$\mathcal{S}_2^j(E, a_2) = \begin{cases} \frac{\{W_2^j(E, a_2)/\eta[p, w^j(E)]\}^{1-1/\sigma} - 1}{1 - 1/\sigma} & \text{if } \sigma \neq 1 \\ \ln \left\{ \frac{W_2^j(E, a_2)}{\eta[p, w^j(E)]} \right\} & \text{if } \sigma = 1. \end{cases} \quad (4)$$

Married Couples in Period 2. An individual of gender j who gets married at the start of period 2 is matched to a spouse of the opposite sex $-j$ as described below. Due to economies of scale, the cost of providing two household members with the same amount of the consumption good is less than twice that for a single person. I denote by $1 < e \leq 2$ the so-called equivalence scale for two adult individuals.

The household maximizes the common utility flow of its members subject to a budget constraint and given the home production technology. Implicitly, I assume that the couple behaves as a “unitary” household.

¹ See Online Appendix B for more details.

Alternatively, they could bargain over the household allocation (see the discussion below). The optimal solution is very similar to that of a single, but with an important difference, namely that both spouses can devote time to home production. I define $\psi[w^j(E^j), w^{-j}(E^{-j})]$ as the lowest possible cost of one unit of “home time” as a function of the individual wage rates. As long as spouses are imperfect substitutes ($\xi \ll \infty$), both will contribute a positive amount of time to home production, but the person with the lower wage does most. The price of the consumption good is then $\eta\{p, \psi[w^j(E^j), w^{-j}(E^{-j})]\}$, where η is the minimum cost function derived for a single above.

The level of utility for a married individual, conditional on their own education level and premarital savings, and those of their spouse, is given by

$$\mathcal{M}_2^j(E^j, E^{-j}, a_2^j, a_2^{-j}) = \begin{cases} \left[\frac{W_2(E^j, E^{-j}, a_2^j + a_2^{-j})}{\eta\{p, \psi[w^j(E^j), w^{-j}(E^{-j})]\}e} \right]^{1-1/\sigma} - 1 & \text{if } \sigma \neq 1 \\ \ln \left[\frac{W_2(E^j, E^{-j}, a_2^j + a_2^{-j})}{\eta\{p, \psi[w^j(E^j), w^{-j}(E^{-j})]\}e} \right] & \text{if } \sigma = 1, \end{cases} \quad (5)$$

where $W_2(E^j, E^{-j}, a_2) = [1+r]a_2 + w^j(E^j) + w^{-j}(E^{-j})$ is joint financial and human wealth.

Education Choice in Period 1. In the first period, each person decides whether to get an education or not and how much to save for the next period, taking the choices made by all other individuals as given. Conditional on gender j and the education choice E , the problem can be written as

$$\begin{aligned} S_1^j(E) = \max_{x, n, a} \left\{ u[g(x, n)] + \frac{1}{1+\rho} \left[(1-q)S_2^j(E, a) \right. \right. \\ \left. \left. + q\{\pi^{-jlj}(0|E)\mathcal{M}_2^j[E, 0, a, \mathbf{a}_2^{-j}(0)] \right. \right. \\ \left. \left. + \pi^{-jlj}(1|E)\mathcal{M}_2^j[E, 1, a, \mathbf{a}_2^{-j}(1)] \right] \right\}, \end{aligned} \quad (6)$$

subject to the budget constraint $a = w^j(E)[1-n] - px$ and given the home production technology. The first term in the objective function is the instantaneous felicity from the consumption good in period 1. The remaining terms capture the expected utility in period 2, discounted at the rate of impatience ρ . With probability $1-q$, the individual remains single and has utility $S_2^j(E, a)$. If this person marries, then there is a probability

$\pi^{-j|j}(0|E)$ of being matched to an uneducated spouse with financial wealth $\mathbf{a}_2^{-j}(0)$, and a probability $\pi^{-j|j}(1|E)$ of finding an educated partner who brings along $\mathbf{a}_2^{-j}(1)$ in savings. The choices of market goods, home hours, and savings that solve this problem are denoted by $\mathbf{x}_1^j(E)$, $\mathbf{n}_1^j(E)$, and $\mathbf{a}_2^j(E)$, respectively.

The choice of whether or not to get an education comes down to a comparison of expected utility levels. It is optimal to obtain a college degree if the utility cost of education θ is below a gender-specific threshold $\bar{\theta}^j = S_1^j(1) - S_1^j(0)$.² It follows that the fraction of educated individuals of gender j is $\pi^j(1) = F(\bar{\theta}^j)$, which corresponds to the mass in the left tail of the utility-cost distribution.

The Marriage Market

As stated above, I assume that a fraction q of individuals get married at the start of period 2. This leaves open the question of who is matched with whom. I will ensure that the model remains tractable by assuming that individuals take the matching probabilities as given. Related studies that use an endogenous matching framework are Greenwood *et al.* (2016) and Guvenen and Rendall (2015).

I let $\pi^j(E)$ denote the fraction of individuals of gender $j \in \{f, m\}$ with education level $E \in \{0, 1\}$. Naturally, $\pi^j(0) + \pi^j(1) = 1$. I write $\pi(E^f, E^m)$ for the probability that a female with education E^f is matched with a male with education E^m . Despite the popular saying that “opposites attract”, most people tend to get married to someone with a similar level of education.³ This type of marital sorting is known as positive assortative matching or homogamy, and it might arise because of complementarities between spouses or simply because individuals who are alike are more prone to meet and fall in love. To allow for this kind of behaviour, I define

$$\pi(1, 1) = (1 - \lambda)\pi^f(1)\pi^m(1) + \lambda \min \{ \pi^f(1), \pi^m(1) \}, \quad (7)$$

where the parameter λ is an index of the degree of marital sorting. If $\lambda = 0$, then matching is random. If $\lambda = 1$, then matching is perfectly positively assortative, so that the probability of a match between two educated individuals is determined by whether educated men or educated

² More precisely, at the start of period 1, the state variable is the utility cost of education θ and the problem of an individual of gender j is to solve $V_1^j(\theta) = \max_E \{S_1^j(E) - \theta E\}$. The optimal solution to this problem is a policy function for E that satisfies a threshold rule: $E^j(\theta) = 1$ if $\theta \leq \bar{\theta}^j \equiv S_1^j(1) - S_1^j(0)$ and 0 otherwise.

³ See, for example, the matching patterns from the data in Section IV.

		E^f		
		0	1	
E^m	0	$\pi(0, 0)$	$\pi(1, 0)$	$\pi^m(0)$
	1	$\pi(0, 1)$	$\pi(1, 1)$	$\pi^m(1)$
		$\pi^f(0)$	$\pi^f(1)$	1

Fig. 3. Matching probabilities

women are in short supply. In the special case that $\pi^f(1) = \pi^m(1)$, λ equals the correlation coefficient between female and male education (as in Fernández and Rogerson, 2001). The expression for $\pi(0, 0)$ is similar, and the remaining probabilities follow (see Figure 3).

The probability that a woman is matched to a man with education E^m , conditional on her own educational attainment E^f , follows from Bayes' rule,

$$\pi^{m|f}(E^m|E^f) = \frac{\pi(E^f, E^m)}{\pi^f(E^f)}, \quad (8)$$

with an analogous result for men. If $0 < \lambda \leq 1$, so that there is positive assortative matching, then the probability of being coupled with an educated husband is greater for an educated woman than for an uneducated one; that is, $\pi^{m|f}(1|1) > \pi^{m|f}(1|0)$.

Figure 4 provides a schematic overview of the matching process. Starting from the sides, women (left) and men (right) choose to become educated or not. A fraction q gets married while the remainder stays single. Given marriage, the conditional probabilities determine which type of woman ends up with which type of man.

Equilibrium

Although individuals take the probability of finding a specific type of spouse as given, the beliefs that they have about matching probabilities and savings should be consistent with the actual choices in equilibrium.

Definition 1. *The equilibrium of the model is a set of education frequencies $\{\pi^f(1), \pi^m(1)\}$ and a set of financial asset choices $\{\mathbf{a}_2^f(0), \mathbf{a}_2^f(1), \mathbf{a}_2^m(0), \mathbf{a}_2^m(1)\}$, such that for each gender $j \in \{f, m\}$ and each realization of the utility cost θ from the distribution F , the choice of education E and*

Fig. 4. Matching process

the corresponding level of assets $\mathbf{a}_2^j(E)$ jointly maximize expected lifetime utility.

The optimal choice of financial assets to take along to the second period, $\mathbf{a}_2^j(E)$, depends negatively on the savings of educated and uneducated individuals of the opposite sex. This means that financial assets are strategic substitutes in the marriage game.

In general, it is not possible to solve for the equilibrium analytically. The numerical strategy is outlined in Online Appendix D.

III. Decomposing the Benefit of Education

To gain insight into the considerations that drive the individual's education choice, I decompose the threshold level into two parts: $\bar{\theta}^j = LMB^j + MMD^j$. The first part is the labour-market benefit. In line with Chiappori *et al.* (2009), it is defined as the benefit of education for a person who knows for certain that they will never marry (referred to as a “lifelong single” hereafter). That is, $LMB^j \equiv \mathcal{L}_1^j(1) - \mathcal{L}_1^j(0)$, where $\mathcal{L}_1^j(E)$ is the maximum level of lifetime utility for a person with education E in the absence of marriage prospects

$$\mathcal{L}_1^j(E) = \max_{\{x_t, n_t\}_{t=1}^2} \left\{ u[g(x_1, n_1)] + \frac{1}{1+\rho} u[g(x_2, n_2)] \right\}, \quad (9)$$

given the home production technology and a lifetime budget constraint

$$c_1 + px_1 + \frac{c_2 + px_2}{1+r} = w^j(E)[1 - n_1] + \frac{w^j(E)(1 - n_2)}{1+r}. \quad (10)$$

Note that, in this model, such a lifelong single does not actually exist, as everyone faces uncertainty about whether they will marry or not. The remaining part of the threshold consists of the marriage-market distortion: $MMD^j \equiv SB^j + q[UG^j + MP^j]$. The possibility of marriage distorts the education decision in several ways. First, it affects the amount of pre-marital savings. The financial asset choices in the equilibrium $\mathbf{a}_2^j(E)$ are different from those of a hypothetical lifelong single. For example, the prospect of marrying a rich spouse might make an individual save less, while the possibility of getting a financially dependent partner could increase savings. If someone turns out to remain single after all, then actual lifetime utility will differ from that of a lifelong single.⁴ This affects the benefit of education for a single. Therefore, I define the part of the marriage-market distortion explained by changes in savings behaviour as

$$SB^j \equiv \left[u\{g[\mathbf{x}_1^j(1), \mathbf{n}_1^j(1)]\} + \frac{1}{1+\rho} \mathcal{S}_2^j[1, \mathbf{a}_2^j(1)] - u\{g[\mathbf{x}_1^j(0), \mathbf{n}_1^j(0)]\} \right. \\ \left. - \frac{1}{1+\rho} \mathcal{S}_2^j[0, \mathbf{a}_2^j(0)] \right] - [\mathcal{L}_1^j(1) - \mathcal{L}_1^j(0)], \quad (11)$$

where $\mathbf{x}_1^j(E)$, $\mathbf{n}_1^j(E)$, and $\mathbf{a}_2^j(E)$ are the policy functions for period 1 as defined above. Second, the expected utility gain from being educated is different when married compared with being single:

$$UG^j \equiv \frac{1}{1+\rho} \left[\pi^{-j|j}(1|0) \{ \mathcal{M}_2^j[1, 1, \mathbf{a}_2^j(1), \mathbf{a}_2^{-j}(1)] \right. \\ - \mathcal{M}_2^j[0, 1, \mathbf{a}_2^j(0), \mathbf{a}_2^{-j}(1)] \} + \pi^{-j|j}(0|0) \\ \times \{ \mathcal{M}_2^j[1, 0, \mathbf{a}_2^j(1), \mathbf{a}_2^{-j}(0)] - \mathcal{M}_2^j[0, 0, \mathbf{a}_2^j(0), \mathbf{a}_2^{-j}(0)] \} \\ \left. - \{ \mathcal{S}_2^j[1, \mathbf{a}_2^j(1)] - \mathcal{S}_2^j[0, \mathbf{a}_2^j(0)] \} \right]. \quad (12)$$

The first two terms capture the expected increase in welfare from education when married, keeping the probability of being matched to a certain type of spouse fixed at that for an uneducated person. This is contrasted to the increase in utility from education when single. The final part of the marriage-market distortion can be ascribed to matching probabilities:

⁴ To be precise, it will be less for each education level. Because $\mathcal{L}_1^j(E)$ is, by definition, the maximum level of lifetime utility for someone of gender j with education E who remains single, any deviation from the corresponding savings choice will lower lifetime utility.

$$MP^j \equiv \frac{1}{1+\rho} [\pi^{-j|j}(0|0) + \pi^{-j|j}(1|1) - 1] \\ \times \{ \mathcal{M}_2^j[1, 1, \mathbf{a}_2^j(1), \mathbf{a}_2^{-j}(1)] - \mathcal{M}_2^j[1, 0, \mathbf{a}_2^j(1), \mathbf{a}_2^{-j}(0)] \}. \quad (13)$$

If there is positive assortative matching, then being educated has the advantage of increasing the probability of marrying an educated spouse, assuming that this is desirable. If the matching process is completely random, then this term disappears because the conditional probabilities in the first set of brackets coincide with the unconditional ones and sum to unity. As in Guvenen and Rendall (2015), the prevalence of sorting in the marriage market gives rise to an externality in the choice of education. For example, suppose that there are fewer educated women than educated men, such that $\pi^f(1) < \pi^m(1)$. This implies that, even with perfect assortative matching, some educated men will marry uneducated women. If more women decide to get a college education, then an uneducated woman becomes less likely to find an educated spouse, which leads to an increase in MP^f , and thereby (ceteris paribus) a higher benefit of education for women.

The last two components of the distortion taken together (i.e., $UG^j + MP^j$) comprise what is sometimes thought of as a “marriage-market benefit” of education (as in Chiappori *et al.*, 2009). It can be either positive or negative, depending on how the education level of the partners affects the amount of surplus generated by marriage and how this surplus is divided between them. The estimates provided by Ge (2011) show that marriage benefits are a quantitatively important part of the returns to education for women.

I will discuss possible gender differences in the labour-market benefit of education and marriage-market distortion in turn.

The Labour-Market Benefit

Recall that the labour-market benefit of education is the difference in lifetime utility with and without education for a person who remains single for certain. It can be written as

$$LMB^j = \begin{cases} \Gamma_1(\sigma)^{-1/\sigma} \frac{\left\{ \frac{W_1^j(1)}{\eta[p, w^j(1)]^{1-\varepsilon}} \right\}^{1-1/\sigma} - \left\{ \frac{W_1^j(0)}{\eta[p, w^j(0)]^{1-\varepsilon}} \right\}^{1-1/\sigma}}{1-1/\sigma} & \text{if } \sigma \neq 1 \\ \frac{2+\rho}{1+\rho} \ln \left\{ \frac{\eta[p, w^j(0)] W_1^j(1)}{\eta[p, w^j(1)] W_1^j(0)} \right\} & \text{if } \sigma = 1, \end{cases} \quad (14)$$

where human wealth $W_1^j(E) = w^j(E)[2+r]/[1+r]$ is equal to the discounted value of wages and $\Gamma_1(\sigma)$ is the marginal propensity to consume in the first period:

$$\Gamma_1(\sigma) = \left[1 + \frac{1}{1+r} \left(\frac{1+r}{1+\rho} \right)^\sigma \right]^{-1}. \quad (15)$$

Gender differences in the labour-market benefit of education can stem from several sources. First, there is ample evidence for the existence of a “gender wage gap”: after accounting for measurable skills, women earn less than men (see Jarrell and Stanley, 2004, for a meta-analysis for the US). In addition, men and women might not receive the same college wage premium, which is a measure of how much more a college graduate earns compared with a person without such a degree. Usually it is defined as the log difference in wages $\ln[w^j(1)/w^j(0)]$. It corresponds to the coefficient on a college dummy in a Mincerian-style semi-log wage regression. Several authors have argued that the college wage premium is higher for women, as obtaining an education gives them a double dividend: not only does it increase their productivity, but it also reduces the gender gap in wages. Dougherty (2005) attributes this gap to “discrimination, tastes and circumstances”, all of which might be inversely related to a woman’s educational attainment. Similarly, Chiappori *et al.* (2009) postulate that discrimination is weaker against educated women, because they are expected to show more labour-market commitment and to invest more on the job. In contrast, Hubbard (2011) claims that the gender difference in the college wage premium is actually a statistical fluke that is the result of censoring of the highest wages in the data. As these top wages are disproportionately earned by men, ignoring the fact that they are recorded only up to a maximum tends to depress the male college wage premium. After correcting for this “topcoding bias”, he finds that there has not been a significant gender difference in the college wage premium for at least a decade.

In the context of the model, with log felicity ($\sigma = 1$) and only market goods in home production ($v = 1$), the labour-market benefit of education is linearly increasing in the college wage premium. In this case, only relative wages of educated and uneducated workers matter for the education threshold $\hat{\theta}^j$, and a higher college wage premium for one of the sexes immediately translates into a higher labour-market benefit. However, with $\sigma \neq 1$, the absolute wage levels also matter, as the following proposition illustrates.

Proposition 1. *Assume there is no time input in home production. If the college wage premium is the same for both sexes but women earn less than equally qualified men, then*

$$LMB^f \gtrless LMB^m \Leftrightarrow \sigma \gtrless 1.$$

Differences in the labour-market benefit between the sexes depend positively on the common college wage premium.

Proof: See Appendix A. □

Hence, even with a common college wage premium, there might be a gender difference in the labour-market benefit of education that is solely attributable to the curvature of the utility function. To understand this, note that, under the assumption of perfect capital markets, the utility level of a lifelong single is an increasing function of individual wealth. I write the indirect utility function as $\mathcal{L}_1^j(E) = V[W_1^j(E)]$. The labour-market benefit is defined as the difference in lifetime utility with and without education for a lifelong single (see Figure 5(a)). By a first-order approximation, it can be written as

$$\begin{aligned} LMB^j &\approx V'[W_1^j(0)][W_1^j(1) - W_1^j(0)] \\ &= V'[W_1^j(0)]W_1^j(0) \left[\frac{W_1^j(1)}{W_1^j(0)} - 1 \right], \end{aligned} \quad (16)$$

where $W^j(1)/W^j(0)$ is, by assumption, the same for men and women. By taking the derivative of equation (16) with respect to $W_1^j(0)$ while keeping $W_1^j(1)/W_1^j(0)$ fixed, I obtain

$$\frac{\partial LMB^j}{\partial W_1^j(0)} = V'[W_1^j(0)]\{1 - \zeta[W_1^j(0)]\} \left[\frac{W_1^j(1)}{W_1^j(0)} - 1 \right], \quad (17)$$

where ζ is the elasticity of the (indirect) marginal utility of wealth:

$$\zeta(W) = -\frac{V''(W)W}{V'(W)}. \quad (18)$$

Within the framework of expected utility and with an isoelastic felicity function as specified in equation (1), $\zeta = 1/\sigma$ is constant and equal to the coefficient of relative risk aversion. Figure 5(b) depicts the utility function for several values of ζ in order to illustrate the difference in curvature. The higher ζ is, the faster marginal utility declines as wealth increases. The sign of the derivative in equation (17) depends solely on whether ζ is greater or smaller than unity. Estimates based on US consumption data indicate that the intertemporal substitution elasticity is between zero and one (see Attanasio and Weber, 1995), while estimates of the degree of relative risk aversion are usually greater than one (see Meyer and Meyer, 2005). Most macroeconomic models are therefore calibrated with $\sigma < 1$, which results in

Fig. 5. Curvature of the indirect utility function

a strongly diminishing marginal utility of wealth. In the presence of a gender wage gap, it follows that women, for whom $w^j(0)$ and thus $W_1^j(0)$ is lower, have a higher labour-market benefit of education than men. This difference is greater the larger the common college wage premium is.

In the more general case where both market goods and home time feature in the home production technology, the elasticity of substitution γ plays an important role. By assumption, the home production technology has constant returns to scale. This implies that the minimum cost function is linear homogeneous in p and $w^j(E)$. Hence, I can write

$$\frac{\eta[p, w^j(1)]}{\eta[p, w^j(0)]} = \frac{\eta[p/w^j(0), w^j(1)/w^j(0)]}{\eta[p/w^j(0), 1]}. \quad (19)$$

With a common college wage premium, there is only a gender difference in $p/w^j(0)$. As men earn higher wages, they can more easily afford market inputs. If time and goods are gross substitutes ($\gamma < 1$), then this raises the benefit of a college education for men relative to women. For the case of gross complements ($\gamma > 1$), it is exactly the other way around.

The Marriage-Market Distortion

The marriage-market distortion is difficult to analyse analytically, as it depends on the matching probabilities, which are themselves determined in the overall equilibrium. By keeping the probabilities constant across the sexes, I derive some partial equilibrium insights.

Consider the simplest possible case with log felicity, no savings and no time input in home production. Then the level of utility in the second period is increasing in the log of household wealth. The part of the marriage market distortion explained by changes in the utility gain from education is then given by:

$$\begin{aligned}
 UG^j = \frac{1}{1+\rho} & \left\{ \pi^{-j|j}(1|0) \ln \left[1 + \frac{w^j(1) - w^j(0)}{w^j(0) + w^{-j}(1)} \right] \right. \\
 & + \pi^{-j|j}(0|0) \ln \left[1 + \frac{w^j(1) - w^j(0)}{w^j(0) + w^{-j}(0)} \right] \\
 & \left. - \ln \left[1 + \frac{w^j(1) - w^j(0)}{w^j(0)} \right] \right\}. \quad (20)
 \end{aligned}$$

The first two terms capture the expected return to education when married, which is compared with the corresponding return in the single state. It is clear that, under these assumptions, $UG^j < 0$. The absolute increase in wages that comes from an education $w^j(1) - w^j(0)$ does not depend on whether a person ends up being married or single from period 2 onward; yet, if there is already some spousal income $w^{-j}(E^{-j})$, then this yields relatively less additional utility. In other words, with diminishing marginal utility of wealth, a married person has less to gain from an education than a single individual. If the college wage premium is the same for both sexes, but women earn less than equally qualified men, then $UG^f < UG^m$, because the absolute wage differential is smaller for a woman, and she can expect to marry a richer spouse, which provides her with fewer incentives to accumulate human wealth.⁵

Concerning the part of the marriage-market distortion attributable to matching probabilities, it is exactly the other way around:

$$MP^j = \frac{1}{1+\rho} \left[\pi^{-j|j}(0|0) + \pi^{-j|j}(1|1) - 1 \right] \ln \left[1 + \frac{w^{-j}(1) - w^{-j}(0)}{w^j(1) + w^{-j}(0)} \right]. \quad (21)$$

As wages for women are lower, they have more to gain than men by marrying an educated spouse compared with an uneducated spouse, such that $MP^f > MP^m$. Matters become more complicated once I allow for time inputs in home production because a college education implies not only a greater amount of human wealth but also a higher opportunity cost of time spent at home. As a result of the gender wage gap, a woman is more likely to be the spouse that earns the lowest wage and therefore contributes, on average, more hours to home production.

Overall, it is likely that, in the presence of a gender wage gap, $MMD^f < MMD^m$, so that the marriage-market distortion lowers the education threshold of women relative to men.

⁵ If $w^f(1)/w^f(0) = w^m(1)/w^m(0)$ but $w^f(0) < w^m(0)$, it follows that $w^f(1) - w^f(0) < w^m(1) - w^m(0)$ and $w^f(1) + w^m(0) < w^f(0) + w^m(1)$.

IV. Parametrization

In this section, I parametrize the model in order to solve for the equilibrium numerically. Where possible, I take parameter values directly from the data or the relevant body of literature.

Data

I use census data from the Integrated Public Use Microdata Series for the US (Ruggles *et al.*, 2010; see Online Appendix C for a description). I pick two cohorts, one born in 1950 and one born in 1970. When they are 40 years of age (in 1990 and 2010, respectively), I obtain some key statistics. The first two lines of Table 1 give the proportion of women and men of each cohort who have obtained at least a Bachelor's degree. For the 1950 cohort, the fraction of educated men exceeded that of educated women, but by 1970 this inequality had been reversed.

Figure 6 shows how men and women are matched in the data. Unfortunately, it is not possible to retrieve information about the characteristics of the former spouse for individuals who are separated or divorced, so the matching pattern is solely based on those who are (still) married at age 40, or are cohabiting.⁶ The second row and second column do not add up exactly to $\pi^m(1)$ and $\pi^f(1)$, respectively, because, in reality, marriage rates are not independent of education level and because spouses need not be of the exact same age. From these cross-tables, I compute the index of marital sorting λ (see Table 1). It is greater than zero, indicating that there is positive assortative matching in education. Over time, λ has remained virtually constant. Other studies have claimed that marital sorting has become stronger (see Fernández *et al.*, 2005), yet this conclusion is often based on the correlation coefficient between male and female education, which indeed increased from 0.472 for the 1950 cohort to 0.523 for individuals born in 1970.⁷ The rise in correlation can be entirely explained by the increased supply of educated women $\pi^f(1)$ without any change in the underlying preferences for assortative matching λ – a similar conclusion is reached by Chiappori *et al.* (2011) in the context of a different model. I calculate the probability of marriage q as one minus the fraction of people who are classified as “never

⁶ I define a cohabiting couple as one in which a “household head” lives together with an “unmarried partner” with a maximum age difference of 10 years. See Online Appendix C.

⁷ The correlation coefficient is given by

$$cor = \lambda \frac{\min\{\pi^f(1), \pi^m(1)\} - \pi^f(1)\pi^m(1)}{\sqrt{\pi^f(1)[1 - \pi^f(1)]}\sqrt{\pi^m(1)[1 - \pi^m(1)]}}.$$

Table 1. *Graduation rates and matching parameters*

	Cohort 1950	Cohort 1970
$\pi^f(1)$	0.252	0.337
$\pi^m(1)$	0.304	0.291
q	0.905	0.830
λ	0.563	0.564

Source: Integrated Public Use Microdata Series for 1990 and 2010.

Fig. 6. Matching patterns

Source: Integrated Public Use Microdata Series for 1990 and 2010.

married/single” and are not cohabiting. Table 1 shows that this probability has declined significantly over time.

Parameter Values

I assume that the length of each period is 30 years. The interest rate is set at 3 percent and the impatience discount factor at 1 percent per annum. The market good is taken to be the numeraire, so that $p = 1$. I normalize the wage of an uneducated male to unity and assume that uneducated women earn $w^f(0) = 0.75$, so that the male-to-female wage ratio is $1/\chi \approx 1.33$, which is consistent with the average findings for the gender wage gap in the US as reported in the meta-analysis of Jarrell and Stanley (2004). The cohort born in 1950 will be active in the labour market from 1970 up to 2010. From Hubbard (2011), I take the average value of the college wage premium for these years and set $\ln[w^j(1)/w^j(0)] = 0.5$ for both sexes.

I choose an intertemporal substitution elasticity equal to $\sigma = 0.5$, which implies that the elasticity of the marginal utility of wealth is $\zeta = 2$. Below, I will discuss the robustness of the results for different values of σ .

The elasticity of substitution between time and market goods in home production is taken from Aguiar and Hurst (2007), who estimate it to be roughly equal to $\gamma = 1.8$. This implies that the two inputs are gross substitutes. I assume that the unit time endowment corresponds to 60 hours of time available per week for working at home and in the market; this is consistent with evidence from time-use data (see Knowles, 2013). The weight of market goods in the home production technology $\nu = 0.604$ is set in such a way that a single uneducated male works 40 hours per week in the second period. This value for ν is very close to that estimated by Guvenen and Rendall (2015). The elasticity of substitution between men and women in the production of home time is $\xi = 3$, which is in line with the estimates of Knowles (2013) from US data and Lise and Yamada (2015) for Japanese households.⁸ The Organisation for Economic Co-operation and Development (OECD) equivalence scale for two adults equals $e = 1.7$.

The remaining parameters are set in such a way as to match some of the key statistics for the 1950 cohort. The marital sorting index is $\lambda = 0.563$ and the probability of marriage $q = 0.905$, as in the data. After calculating the threshold values for education (with $\bar{\theta}^f < \bar{\theta}^m$), I choose the parameters of a lognormal utility-cost distribution to ensure that the cumulative density equals $\pi^f(1) = 0.252$ at $\bar{\theta}^f$ and $\pi^m(1) = 0.304$ at $\bar{\theta}^m$.

V. The College Gender Gap Reversal

In this section, I will use the model to understand why women have overtaken men in terms of educational attainment. I consider three exogenous driving forces: a decrease in the probability of marriage, a decrease in the gender wage gap, and an increase in the college wage premium.

For the chosen parameter values, the black lines in Figure 7 depict combinations of the probability of marriage q and the female-to-male wage ratio χ that yield a symmetric equilibrium with $\pi^m(1) = \pi^f(1)$. There is a vertical line at $\chi = 1$, because, in the absence of a gender wage gap, men and women are exactly the same and college graduation rates will be equal. For the given parameter values (in particular $\sigma < 1$), the labour-market benefit of education for women is greater than that for men as long as $\chi < 1$ (recall Proposition 1). This explains why $\pi^f(1) > \pi^m(1)$ if the probability of marriage is low. If the probability of marriage is high, then the marriage-market distortion overturns the gender difference in

⁸ Both studies also find that men and women are equally productive, which has already been imposed in equation (3).

Fig. 7. College gender gap reversal

the labour-market benefit of education, so that educated men outnumber educated women. In this case, a man knows that he is likely to end up marrying a wife who earns less than he does, which gives him an incentive to invest in his own education in order to generate a higher level of household income. For a woman, it is the other way around; she is almost certain to marry a richer husband and has little to gain by obtaining more schooling.

The initial equilibrium that represents the 1950 cohort is indicated with a dot at the point where $\chi = 0.75$ and $q = 0.905$. As can be seen from Table 1, marriage rates dropped for the cohort born in 1970. This results in a vertical movement from $q = 0.905$ to $q = 0.803$ in the diagram. In addition, there is a tendency for the gender wage gap to shrink over time. The estimate of Jarrell and Stanley (2004) for a linear time trend in the discrimination coefficient suggests that the female-to-male wage ratio has increased by about 0.10 in 20 years.⁹ This is represented by a movement to the right from $\chi = 0.75$ to $\chi = 0.85$. Finally, the 1970 cohort faces a higher average wage and a higher college wage premium over their lifetime. Increasing the wage earned by an unskilled worker by 15 percent and the common college wage premium to 0.6 results in an upward shift of the line as the labour-market benefit for women increases

⁹The estimated trend for the discrimination coefficient is -0.0079 , so that after 20 years, I have a change of $20 \times -0.0079 = -0.158$. This corresponds to a gender wage gap of $(e^{0.141} - 1) \times 100 \text{ percent} = 15.142 \text{ percent}$ of the female wage, or a female-to-male wage ratio of $1/1.151 \approx 0.868$.

Table 2. *Decomposition of the benefit of education*

		Cohort 1950		Cohort 1970	
		Female	Male	Female	Male
	SB^j	27.009	3.122	11.866	4.847
+	qMP^j	11.899	2.014	8.485	4.174
+	qUG^j	-68.036	-11.937	-41.155	-20.295
=	MMD^j	-29.128	-6.801	-20.804	-11.274
+	LMB^j	129.128	113.286	134.098	123.107
=	$\bar{\theta}^j$	100.000	106.485	113.294	111.833
	$\pi^j(1)$	0.252	0.304	0.360	0.348

relative to that of men (see Proposition 1).¹⁰ Taken together, these changes in wages and the probability of marriage result in a reversal of college graduation rates as the equilibrium for the 1970 cohort is below the grey line.

The decomposition of the benefit of education is given in Table 2. The bottom line gives the education frequencies $\pi^j(1)$ for each gender and cohort. The row above reports the corresponding threshold level $\bar{\theta}^j$. As this number by itself is not very informative, I have chosen to rescale the values in such a way that $\bar{\theta}^j = 100$ for the 1950 cohort. The threshold can be decomposed into the labour-market benefit of education LMB^j and the marriage-market distortion MMD^j (the two lines above). The latter is itself made up of three separate components, namely the parts due to changes in savings behaviour SB^j , the utility gain of education for married individuals versus singles UG^j , and differences in matching probabilities MP^j (recall Section III).

For the 1950 cohort, the labour-market benefit of education is significantly higher for women than for men. However, this is dominated by a much lower value of the marriage-market distortion. In particular, the utility gain of education is considerably smaller for a married woman than for a single, as evidenced by the large negative number reported for UG^j . The intuition for this was given above: a married woman is likely to have a husband who earns more than she does, which, in the presence of diminishing marginal utility of wealth, gives her little incentive to

¹⁰ Guvenen and Rendall (2015) report a yearly wage growth of 0.70 percent for unskilled males, which corresponds to a 15 percent increase over a 20-year period. The relevant college wage premium for the 1970 cohort would be the average between 1990 and 2030. As this is not available, I take the most recent value from Hubbard (2011), which is an average premium of about 0.6 for 2008.

Table 3. *The isolated effects of the driving forces*

	Cohort 1950		Cohort 1970 Marriage rates		Cohort 1970 College premium		Cohort 1970 Gender wage gap	
	Female	Male	Female	Male	Female	Male	Female	Male
LMB^j	129.128	113.286	129.128	113.286	142.450	123.107	122.355	113.286
MMD^j	-29.128	-6.801	-23.815	-8.326	-31.724	-7.180	-22.261	-9.781
$\bar{\theta}^j$	100.000	106.485	105.313	104.960	110.776	115.927	100.094	103.505
$\pi^j(1)$	0.252	0.304	0.295	0.292	0.339	0.381	0.253	0.280

invest in education. Note that the part of the marriage-market distortion attributable to matching probabilities is greater for women than for men, albeit small relative to the other components.

The wage changes result in an increase of the labour-market benefit of education for both men and women, but the effect is smaller for the latter (due to a partial closing of the gender wage gap). Although the marriage-market distortion is still lower for women, it no longer dominates the gender difference in the labour-market benefit of education. As a consequence, the fraction of educated women is greater than that of men for this cohort.

In Table 3, I show the isolated effect of each of the driving forces on the equilibrium outcome. In the first column for the 1970 cohort, I change only the probability of marriage, leaving the wages unchanged. As a result, the labour-market benefit for each gender stays at its value for the 1950 cohort, but the reduction in the marriage-market distortion for women results in a college gender gap reversal. The fraction of educated men decreases, which is also true in the data (see Table 1). The next column shows the combined effect of an increase in the college wage premium and the general level of wages. The education frequencies go up for both men and women, but the difference between them remains more or less the same. Finally, in the last column, I increase only the female-to-male wage ratio. In the absence of other differences between men and women, a reduction in wage discrimination can explain only a catch-up but not a reversal of college graduation rates. These results suggest that the strongest force for a reversal of the college gender gap is the drop in marriage rates. In addition, only this channel can help us understand why the fraction of educated males might have decreased.

The ability of the model to generate a college gender gap reversal depends on the choice of parameters, in particular the elasticity of the marginal utility of wealth $\zeta = 1/\sigma$. In Table 4, I show how the results change under various values of σ . In each case, I have to recalibrate the weight of market goods in the felicity function v to obtain reasonable

Table 4. *Results under alternative parametrizations*

	(1)	(2)	(3)	(4)
σ	0.450	0.500	0.750	1.000
ζ	2.222	2.000	1.333	1.000
v	0.602	0.604	0.616	0.626
$CV(\theta)$	1.831	3.709	15.389	30.490
$\pi^f(1)$	0.383	0.360	0.343	0.345
$\pi^m(1)$	0.319	0.348	0.362	0.369

labour-supply choices and the parameters of the utility-cost distribution in order to match the education frequencies in 1950. Then I perform the same experiment by changing the driving forces.

A higher value of σ implies a lower elasticity of the marginal utility of wealth and a smaller labour-market benefit of education for women relative to men. As a consequence, the threshold values will be further apart in the parametrization, which implies a greater spread in the estimated utility-cost distribution (as measured by the coefficient of variation $CV(\theta)$, the ratio of the standard deviation to the mean). This results in a smaller response to changes in the college wage premium and marriage rates. For values of σ smaller than 0.45, it is not possible to obtain a valid parametrization because the benefit of education for women is too large compared with that for men to be consistent with the education frequencies observed for the 1950 cohort.

I would like to end the discussion with a few more comments. First, the model does not allow for the possibility of divorce, as couples can get married only in the final period of life. Guvenen and Rendall (2015) point to the increase in divorce rates over the last decades as a potential explanation for the surge in female college enrolment. Divorce tends to be more costly for women than for men, as custodial arrangements are usually such that the children reside with their mother. This might incentivize risk-averse women to invest in their financial independence. Although not explicitly modelled in the current paper, a similar incentive mechanism is still at work. In the presence of a gender wage gap, the utility of single women is lower than that of single men, because they earn lower wages. A drop in the probability of marriage then yields a similar response to an increase in the rate of marital dissolution: the ratio of female to male college graduates increases.

Second, many factors are taken as given in the model that need not be independent. For example, an increase in female wages might make them more “picky” in choosing a partner and therefore less prone to

marry (see Caucutt *et al.*, 2002). In addition, they are more likely to “choose love over money”, which would decrease the degree of sorting, as in Fernández *et al.* (2005). If wages depend on work experience, then the increase in female labour supply following a drop in marriage rates might lower the gender wage gap.

Finally, the model makes a few strong assumptions about the behaviour of married couples that can be relaxed. In a previous version of this paper, I have shown that the results go through if I endogenize fertility, allow for Nash bargaining over household allocations, or assume that individuals care for the welfare of their partner (see Reijnders, 2014).

VI. Conclusion

In this paper, I have studied the role of changes in the wage structure and expectations about marriage in explaining the college gender gap reversal. The model I employ allows one to clearly highlight the mechanisms at play. I show which assumptions affect the model’s ability to generate a college gender gap reversal. The most important one is the degree of curvature in the felicity function, which, in the presence of a gender wage gap, gives single women a stronger incentive than single men to invest in education. Intuitively, this is because women earn lower wages, and, with strongly diminishing marginal utility of wealth, they have more to gain by increasing their lifetime earnings through obtaining a college degree. The distortions caused by the marriage market tend to depress the overall benefit of education for women relative to men as they expect to marry a more wealthy spouse and to spend more time on home production. The model can replicate the reversal in college graduation rates between the cohorts born in 1950 and 1970 in the US in response to observed changes in the probability of marriage, the gender wage gap, and the college wage premium. The most important driving force for this reversal seems to be the decline in marriage rates.

Appendix

Proof of Proposition 1: According to the premises of the proposition, $v = 1$ and $w^f(1)/w^f(0) = w^m(1)/w^m(0)$. It follows that $\eta[p, w^j(E)] = p = 1$. The labour-market benefit of education can be written as

$$LMB^j = \Gamma_1(\sigma)^{-1/\sigma} \frac{W_1^j(0)^{1-1/\sigma}}{1-1/\sigma} \left\{ \left[\frac{W_1^j(1)}{W_1^j(0)} \right]^{1-1/\sigma} - 1 \right\}.$$

If $w^j(1)/w^j(0)$ is the same for both sexes, then so is $W_1^j(1)/W_1^j(0)$. Taking the derivative of LMB^j with respect to $W_1^j(0)$ while keeping $W_1^j(1)/W_1^j(0)$ constant gives

$$\frac{\partial LMB^j}{\partial W_1^j(0)} = \Gamma_1(\sigma)^{-1/\sigma} W_1^j(0)^{-1/\sigma} \left\{ \left[\frac{W_1^j(1)}{W_1^j(0)} \right]^{1-1/\sigma} - 1 \right\}$$

$$\stackrel{\leq}{\geq} 0 \Leftrightarrow \sigma \stackrel{\leq}{\geq} 1,$$

because $W_1^j(1)/W_1^j(0) > 1$. The result follows because $W_1^f(0) < W_1^m(0)$ if $w^f(0) < w^m(0)$. In addition

$$\frac{\partial^2 LMB^j}{\partial W_1^j(0) \partial [W_1^j(1)/W_1^j(0)]} = (1 - 1/\sigma) \Gamma_1(\sigma)^{-1/\sigma} W_1^j(1)^{-1/\sigma}$$

$$\stackrel{\leq}{\geq} 0 \Leftrightarrow \sigma \stackrel{\leq}{\geq} 1.$$

□

Supporting Information

The following supporting information can be found in the online version of this article at the publisher's web site.

Online Appendices B, C, and D

References

- Aguiar, M. and Hurst, E. (2007), Measuring Trends in Leisure: The Allocation of Time over Five Decades, *Quarterly Journal of Economics* 122, 969–1006.
- Attanasio, O. and Weber, G. (1995), Is Consumption Growth Consistent with Intertemporal Optimization? Evidence from the Consumer Expenditure Survey, *Journal of Political Economy* 103, 1121–1157.
- Becker, G. S., Hubbard, W. H., and Murphy, K. M. (2010), Explaining the Worldwide Boom in Higher Education of Women, *Journal of Human Capital* 4, 203–241.
- Caucutt, E. M., Guner, N., and Knowles, J. (2002), Why do Women Wait? Matching, Wage Inequality, and the Incentives for Fertility Delay, *Review of Economic Dynamics* 5, 815–855.
- Chiappori, P. A., Iyigun, M., and Weiss, Y. (2009), Investment in Schooling and the Marriage Market, *American Economic Review* 99 (5), 1689–1713.
- Chiappori, P. A., Salanié, B., and Weiss, Y. (2011), Partner Choice and the Marital College Premium, Columbia University Discussion Paper 1011-04.
- Dougherty, C. (2005), Why Are the Returns to Schooling Higher for Women than for Men?, *Journal of Human Resources* 40, 969–988.
- Fernández, R. and Rogerson, R. (2001), Sorting and Long-Run Inequality, *Quarterly Journal of Economics* 116, 1305–1341.

- Fernández, R. and Wong, J. C. (2011), The Disappearing Gender Gap: The Impact of Divorce, Wages, and Preferences on Education Choices and Women's Work, NBER Working Paper 17508.
- Fernández, R., Guner, N., and Knowles, J. (2005), Love and Money: A Theoretical and Empirical Analysis of Household Sorting and Inequality, *Quarterly Journal of Economics* 120, 273–344.
- Ge, S. (2011), Women's College Decisions: How Much Does Marriage Matter?, *Journal of Labor Economics* 29, 773–818.
- Goldin, C., Katz, L. F., and Kuziemko, I. (2006), The Homecoming of American College Women: The Reversal of the College Gender Gap, *Journal of Economic Perspectives* 20 (4), 133–156.
- Greenwood, J., Guner, N., Kocharkov, G., and Santos, C. (2016), Technology and the Changing Family: A Unified Model of Marriage, Divorce, Educational Attainment and Married Female Labor-Force Participation, *American Economic Journal: Macroeconomics* 8, 1–41.
- Gruenen, F. and Rendall, M. (2015), Women's Emancipation Through Education: A Macroeconomic Analysis, *Review of Economic Dynamics* 18, 931–956.
- Hazan, M. and Zoabi, H. (2015), Sons or Daughters? Sex Preferences and the Reversal of the Gender Educational Gap, *Journal of Demographic Economics* 81, 179–201.
- Hubbard, W. H. (2011), The Phantom Gender Difference in the College Wage Premium, *Journal of Human Resources* 46, 568–586.
- Jarrell, S. B. and Stanley, T. D. (2004), Declining Bias and Gender Wage Discrimination? A Meta-Regression Analysis, *Journal of Human Resources* 39, 828–838.
- Knowles, J. (2013), Why Are Married Men Working So Much? An Aggregate Analysis of Intra-Household Bargaining and Labour Supply, *Review of Economic Studies* 80, 1055–1085.
- Lise, J. and Yamada, K. (2015). Household Sharing and Commitment: Evidence from Panel Data on Individual Expenditures and Time Use, IFS Working Paper W14/05.
- Meyer, D. J. and Meyer, J. (2005), Relative Risk Aversion: What Do We Know?, *Journal of Risk and Uncertainty* 31, 243–262.
- Reijnders, L. S. M. (2014), The College Gender Gap Reversal: Insights from a Life-Cycle Perspective, SOM Research Report 14006-EEF, University of Groningen.
- Ríos-Rull, J. V. and Sánchez-Marcos, V. (2002), College Attainment of Women, *Review of Economic Dynamics* 5, 965–998.
- Ruggles, S., Alexander, J. T., Genadek, K., Goeken, R., Schroeder, M. B., and Sobek, M. (2010). *Integrated Public Use Microdata Series: Version 5.0, Machine-readable database*, University of Minnesota, MN.
- Sánchez-Marcos, V. (2007), What Accounts for the Increase in College Attainment for Women?, *Applied Economics Letters* 15, 41–44.

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